BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.
Vol. XII. Article II. With Plates IV—V. August, 1902

ON THE OCCURRENCE OF APLITE, PEGMATITE, AND TOURMALINE BUNCHES IN THE STONE MOUNTAIN GRANITE OF GEORGIA.[1]

By THOMAS L. WATSON.

Aplite and pegmatite.—Careful field study of the larger and principal granite areas in Georgia, by the writer, indicates the general absence of true aplites therefrom. They have been observed in association with the granite masses only at one locality in the state. Since the border portions of the granite masses are usually covered with a considerable depth of residual decay and are seldom exposed, it is not possible to say whether aplites as border phenomena exist, as described by Kemp,[2] in some of the southern Rhode Island and Connecticut granites.

Several aplite dikes less than six inches in width are exposed in the quarries opened on the northwest side of the huge doming ridge known as Stone Mountain, sixteen miles east of Atlanta (Plate IV). Pegmatites are common associates in the Stone Mountain granite and also in the other larger granite masses examined in the state. They consist chiefly of coarse intercrystallizations of potash (orthoclase and microcline) and soda (albite) feldspars with quartz, subordinate amounts of both biotite and muscovite, and occasionally red garnet and tourmaline. So far as my observation goes, the feldspars in the pegmatite greatly exceed in amount the quartz. The granitic pegmatites are sometimes replaced, however, by those of practically pure quartz. In the Stone Mountain pegmatites the dark minerals, mica, tourmaline, and garnet, are frequently concentrated along the central axis of the dike or vein, rather than distributed through the light-colored quartz-feldspar portions. Where observed the granitic pegmatites are monotonously alike, and present no unusual features.

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[1] Reprinted from the JOURNAL OF GEOLOGY, Vol. X, No. 2, February–March, 1902. Pages 186—193.

[2] *Bulletin Geol. Soc. Amer.*, 1899, Vol. X, p. 372.

The principal aplite in the Stone Mountain granite is banded with pegmatite, the aplite forming the border next the granite and the pegmatite the middle layer of the dike. The junctions between the granite, aplite and pegmatite are regular, entirely sharp and well defined. Apart from its being more compact and of much finer-grained texture, the aplite is easily distinguished in the hand specimen from that of the inclosing granite by its lighter color—marble white—and by its containing but little mica. Biotite is entirely absent and muscovite is only sparingly distributed through the rock as minute foils. Occasional very small crystals of red garnet are sometimes present.

In thin section the aplite shows no essential difference in mineral composition from the granite, except in the entire absence of biotite and decreased muscovite. The rock is a holocrystalline mass composed chiefly of the potash (microcline and orthoclase) and soda feldspars, and quartz. Microperthitic structure consisting of interlaminated orthoclase and microcline with a second feldspar, albite, is common. Somewhat irregular, stout laths of a well striated acid oligoclase are numerous. The small percentage of CaO, less than 1 per cent., and the increased Na_2O shown in the analysis, column I, indicates the preponderance of the soda molecule (albite), which is corroborated by the microscope. Sporadic inclusions of apatite occur.

Megascopically, the inclosing rock is a compact, medium-grained biotite-bearing muscovite-granite of light gray, nearly white, color. Biotite is only sparingly distributed through the rock, displaying considerable tendency to segregate in places. Thin sections of the granite show quartz, orthoclase, and microcline frequently intergrown with albite as microperthite, considerable oligoclase, muscovite, occasional biotite, and some prismatic inclusions of apatite.

The striking similarity between the inclosing granite and aplite is sufficiently shown in the chemical analyses of the rocks given below.

The analyses show more SiO_2 and less K_2O in the aplite than in the granite, with close agreement indicated in the other

constituents. A striking feature of the analyses is the low percentage of lime with practically no magnesia, and increased

	I.[1]	II.	Ia.	IIa.
SiO_2	74.30	72.56	1.2383	1.2093
TiO_2	none			
Al_2O_3	14.73	14.81	.1444	.1452
Fe_2O_3[2]	0.78			
FeO		0.85		
MnO	trace			
CaO	0.90	1.19	.0161	.0212
BaO	none			
SrO	none			
MgO	strong trace	0.20		
Na_2O	4.61	4.94	.0743	.0796
K_2O	4.52	5.30	.0481	.0563
H_2O (Ignition)	0.21	0.70		
P_2O_5	trace			
Total	100.05	100.55		

I. Aplite, Stone Mountain, Georgia. Watson, analyst.

II. Stone Mountain granite inclosing aplite. Packard, analyst.

Ia. Molecular ratios of I.

IIa. Molecular ratios of II.

soda, which equals in amount the potash, indicating the predominance of the albite molecule over that of the anorthite, and in case of the aplite the nearly entire absence of magnesia harmonizes with the absence of a ferro-magnesian accessory. Calculating all the lime as anorthite, all the soda as albite, and all the potash as orthoclase or microcline, the mineral composition of the aplite and granite becomes:

	Aplite.	Granite.
Potash feldspar	26.69	31.14
Soda-feldspar	38.77	41.95
Lime-feldspar	4.45	2.50
Quartz	28.30	21.09
Excess of Al_2O_3	.61	
Excess of Fe_2O_3	.78	
Excess of FeO		.85
Excess of MgO		.20
Excess of CaO		.67
Excess of H_2O	.21	.70
	99.81	99.10

[1] Analysis *made* in the chemical laboratory of Denison University.

[2] All iron determined as ferric oxide.

In the aplite there is an access of Al_2O_3 after deducting the amount required of the feldspathic constituent of .0059 molecules corresponding by weight to 0.6 per cent., which is probably combined as mica. From the above calculations the ratio of soda feldspar to lime feldspar is 9 : 1 in the case of aplite and 17 : 1 in the case of the granite, corresponding to lime-bearing albite of Ab_9An_1 and $Ab_{17}An_1$ respectively, when the albite and anorthite molecules are combined to form soda-lime plagioclase. The potash feldspar in both the aplite and granite is part orthoclase and part microcline. According to the calculations the relative abundance of the constituents in the aplite may be expressed as follows: Oligoclase > quartz > orthoclase and microcline > muscovite. In the case of the granite the potash feldspars are slightly in excess of the quartz, otherwise the order of relative abundance of the constituents is the same as for the aplite.

	I.	II.	III.	IV.	V.	VI.
SiO_2	75.07	76.03	76.00	74.21	77.14	74.30
TiO_2	0.09	0.07	0.04	0.30	0.29	none
Al_2O_3	13.07	13.39	14.88	14.47	12.24	14.73
Fe_2O_3	0.61	0.48	0.65	0.35	0.29	0.78
FeO	0.39	0.31	0.10	0.50	1.04	
MnO	trace	trace	trace	none	trace	none
CaO	1.49	1.28	0.19	1.71	0.35	0.90
SrO	0.03	trace	none	trace		none
BaO	0.14	0.04	trace	none		none
MgO	0.14	0.05	0.06	0.28	0.06	strongtrace
K_2O	5.62	5.18	2.77	0.10	4.47	4.52
Na_2O	2.51	2.98	3.52	7.62	4.64	4.61
Li_2O	trace	none	0.20	trace		
H_2O at 100°	0.14	0.15	{ 1.42 }	0.15	{ 0.14 }	{ 0.21 }
H_2O above 100°	0.24	0.34		0.23		
P_2O_5	trace	0.03	0.11	0.07		trace
	100 44	100.33	99.94	99.99	100.66	100.05

I and II. Potash aplites. Described by H. W. Turner, JOUR. GEOL., 1899, Vol. VII, p. 160; also *Seventeenth Ann. Rept. U. S. Geol. Surv.*, p. 521. W. F. Hillebrand, analyst.

III and IV. Soda aplites. Described by H. W. Turner, JOUR. GEOL., 1899, Vol. VII, p. 152. III, W. F. Hillebrand, analyst. IV, H. N. Stokes, analyst.

V. Aplite. Described by H. S. Washington, JOUR. GEOL., 1899, Vol. VII, p. 107. H. S. Washington, analyst.

VI. Aplite. Stone Mountain, Georgia. Thomas L. Watson, analyst.

The percentage ratio of the alkalies in aplites, potash and soda forms a ready basis for grouping them into potash-aplites, soda-aplites, and aplites of equal potash and soda percentages. The Stone Mountain aplite, as shown in the analyses, forms a striking illustration of the third or last type in which the percentage ratio of the potash to soda is equal. To make more emphatic this grouping, and for convenience of comparison, I have tabulated above analyses of some of the recently described well-known aplites from the eastern and western United States:

Tourmaline areas.—A noteworthy feature of the Stone Mountain granite is the somewhat abundant occurrence of small areas of aggregated black tourmaline crystals throughout the entire mass of granite, so far as revealed by quarry operations. Hardly a block of the stone is quarried that does not show a few of these areas. The occurrence of the mineral is not that of a characterizing accessory, as has been noted in some granites, as at Predazzo in the Tyrol, in which the tourmaline takes the place of mica or amphibole, but is more after the order of segregations in the biotite-bearing muscovite granite. Neither are the tourmaline aggregates sufficiently numerous and crowded together in the granite, nor of large enough size, to add to the color of the rock. While clearly visible in every case they do not in any measure detract from the good qualities of the stone for building purposes, for the reasons already stated, and also because of the practical unalterable nature of tourmaline under normal atmospheric conditions.

The tourmaline rarely occurs as isolated or single crystals in the granite proper, but nearly always as radiating and roughly parallel groups, which occupy the centers of perfectly white areas of quartz and feldspar, from which the two micas, muscovite and biotite, have been excluded. The quartz-feldspar areas vary in size from a fraction to several inches in diameter, according to the number of grouped single tourmaline individuals occupying it; and in shape they vary from oblong, irregularly rectangular to complete spherical or circular outlines, with all gradations between. The tourmaline individuals consist of slender prismatic forms, varying from a fraction to several milli-

meters in cross-section without terminal faces; jet-black in color; and in every case examined they are considerably fractured. The number of individuals in a group varies greatly, usually from a half dozen, or thereabouts, to several times that number. The width of the border zone of the feldspar-quartz areas, or that portion of the white mass extending from the outer part of the tourmaline aggregate to the junction formed with the gray granite, is also variable, but is wider in proportion to the size of aggregate occupying the center, and is apparently proportional therefore to the intensity of the action controlling the tourmaline formation.

The quartz-feldspar areas are as strongly contrasted in color with the light gray granite as are the black tourmalines. The junction between the areas and the granite are entirely sharp and distinct, and in no case observed is there any tendency shown toward a gradation or merging of color of the white mass into the granite.

A number of thin sections of the feldspar-quartz areas and their included tourmaline aggregates were examined microscopically. The sections indicated a mosaic of interlocking quartz and feldspar, similar in all respects to, and consisting of the same feldspar species as the granite. No difference in texture and size of the component grains from that of the granite is observed. With few exceptions the feldspars were perfectly fresh. Cataclastic structure is quite strongly accentuated in the feldspar and quartz grains, the cracks are rather wide, and are now filled with a colorless, high double refracting mineral. Primary muscovite is not present in those slides examined, but plentiful small foils of the mineral distributed over the feldspar surfaces are seen in places, and from its association must be regarded as distinctly secondary. In transmitted light the tourmaline is deep brown in color and strongly dichroic. It is closely associated with both the quartz and feldspar, filling at times the interspaces. It is more intimately associated with the feldspar, however, and its distribution through some of the large microcline and oligoclase individuals as partially connecting irregular and ragged granules closely resembles the poikilitic

structure. In some cases the tourmaline is entirely confined to the feldspar individual, while in others it cuts well into the quartz and feldspar grains in such way as to clearly indicate its subsequent formation. In cross-section the mineral appears in some cases to be irregularly rounded and granular rather than bounded by sharp crystalline boundaries, but most of it is so very irregular that it is best described as having an exceedingly ragged outline. In a few instances the prism faces are indicated under the microscope. The mode of occurrence of the tourmaline and its association with the feldspar suggests beyond reasonable doubt its derivation in part from the feldspar, by fumarolic action.

The tourmaline cannot be regarded as a product of contact phenomena, since it is generally distributed throughout the entire mass of granite, so far as quarrying operations extend—not more abundant at one point than at another. I have elsewhere shown[1] that the present granite ridge, Stone Mountain, is the unreduced remnant or "core" of a once more extensive mass. The evidence favoring this is that, on the north, west, and south sides of the ridge, a belt of the same granite, reduced to the same general level of the surrounding Tertiary Piedmont plain, skirts the ridge for a distance varying from a quarter to more than a mile in width. In this reduced granite zone numerous quarries have been worked yielding the same beautiful light gray nearly white Stone Mountain granite. The rock quarried in this zone is strikingly free from the tourmaline aggregates, less than a half dozen in all having been observed. The areas, then, are confined to the ridge portion of the granite mass, and do not characterize the border portions of the granite nor of the adjoining schist and gneiss where exposed.

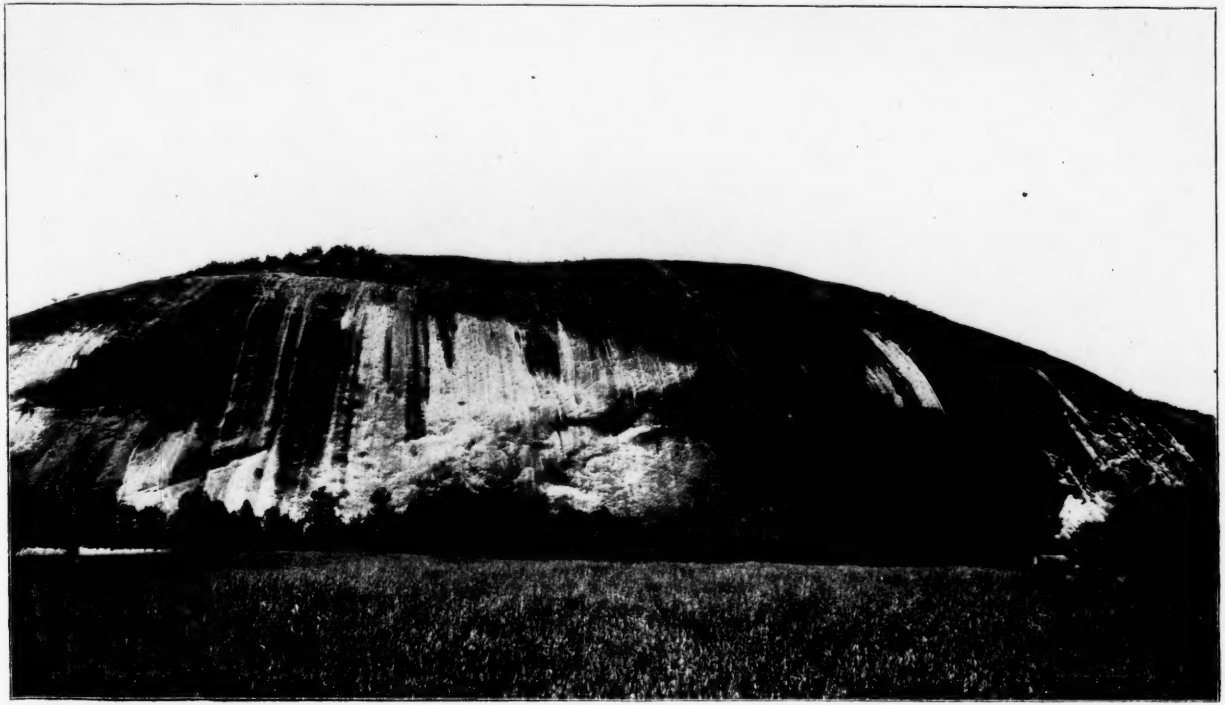
Black tourmaline as isolated single crystals and aggregates is rather a common associate in the Stone Mountain pegmatites, and in several instances veinlets of twelve and more inches long of tourmaline-felt (fine acicular tourmaline), as much as an eighth of an inch in width, have been noted in the granite in

[1] *A Report on the Granites and Gneisses of Georgia, Geological Survey of Georgia.* In press.

the northwest quarries of the ridge. While no distinct evidence bearing on the contemporaneous origin of the tourmaline aggregates in the granite with those of the pegmatite and the tourmaline veinlets, it seems reasonable to assume such contemporaneity.

The very nature of the areas oppose the hypothesis of direct secretion out of the eruptive granite magma. On the other hand, the characteristic mode of occurrence and intimate relationship to certain other mineral species present, as shown both macroscopically and microscopically, make it reasonably certain that the tourmaline areas have resulted from fumaroles highly charged with boric acid acting on the feldspars and mica.

Geological Laboratory, Denison University,
Granville, Ohio.



Stone Mountain, Georgia. An unreduced residual of granite, rising 686 feet in elevation above the surrounding Tertiary Piedmont plain. Seven miles in circumference at its base. (Photograph by W. S. Y.)

A view of one of the quarries opened on the northwest side of Stone Mountain, Georgia. Aplite-pegmatites exposed in places over the floor of quarry, now clear of the quarry waste shown in the foreground of the photograph. (Photograph by W. S. V.)

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ON THE OCCURRENCE OF URANOPHANE IN GEORGIA.[1]

BY THOMAS L. WATSON.

The object of this paper is to describe the occurrence of the rare mineral uranophane from a new locality. State Geologist Yeates first observed the occurrence of the yellow mineral at Stone Mountain, Georgia, in the early nineties and later had Mr. R. L. Packard examine the material chemically in the laboratory of the Georgia Survey. During 1898 and 1899, while engaged in a field study of the Georgia granites, the writer independently noted the occurrence of this mineral at the same locality, as a thin, yellow incrustation coating the faces of many of the joint planes cutting the Stone Mountain granite mass. Specimens were carefully collected and studied in the laboratory of the Survey in Atlanta.

So far as the writer can ascertain, uranophane is reported from only one locality in the United States, namely, Mitchell county, North Carolina.[2] Here the mineral is found incrusting and penetrating gummite as an alteration product at the mica mines. Under the title "On Some New Mineral Occurrences in Canada," G. Chr. Hoffman[3] of the Canadian Geological Survey has recently described the occurrence of uranophane from Ottawa county, Quebec. According to Hoffman, the mineral in Quebec is associated with "gummite, uraninite, black tourmaline, white, light gray, pale olive-green and bluish green apatite, spessartite, monazite, and green and purple fluorite, in a coarse pegmatite vein composed of white and light to dark, smoky-brown quartz, microcline and muscovite, which traverses a gray garnetiferous gneiss." The mineral is further

[1] Reprinted from the AMERICAN JOURNAL of SCIENCE, fourth series, Vol. XIII, pp. 464–466, 1902.

[2] DANA, E. S., A System of Mineralogy, 1893, p. 699.

[3] AM. JOUR. SCI., **11**, pp. 152–153, 1901.

described as an alteration product of gummite, occurring "in small bright lemon-yellow fibrous masses, sometimes in immediate contact with the gummite found coating the uraninite or, *per se*, embedded in the albite immediately surrounding the tourmaline and often invading the latter." In both Quebec and North Carolina the mineral is an alteration product of gummite, and, in this particular, its occurrence is similar for the two localities, while in Georgia the occurrence is entirely different, as will be noted in the following description.

At Stone Mountain, Georgia, sixteen miles east of Atlanta, the mineral uranophane is found as a distinct incrustation, coating the faces of many of the joint planes, which cut the granite boss. It varies from a sulphur-yellow to lemon-yellow in color, the former predominating, and forms an irregular coating not exceeding one-eighth to one-sixteenth of an inch in thickness, usually less. It is tipped or coated with the clear, colorless, and transparent, drop-like forms of the mineral hyalite. The two minerals are so intimately associated that it is almost impossible to effect a complete separation of them.

The Stone Mountain granite, with which the uranophane is associated, is a light gray, medium-grained, biotite-bearing muscovite granite, composed of quartz, orthoclase, microcline and soda-lime (oligoclase) feldspar, muscovite and biotite, with sporadic microscopic accessories. Fresh specimens of the granite were analyzed by Packard in the Survey laboratory with the following results:

SiO_2	72.56
Al_2O_3	14.81
FeO	0.84
CaO	1.19
MgO	0.20
Na_2O	4.94
K_2O	5.30
H_2O (ignition)	0.70
Total	100.4

Several tests were made by the writer on separate portions of the granite for the presence of uranium, with negative results. The yellow powder gave the usual tests before the blowpipe for uranophane. Packard carefully separated, by means of

a lens, a small amount of the yellow mineral from particles of the granite and other possible impurities for chemical analysis. 0.1310 gram of the powder was used, which gave:

SiO_2	18.55
$U(UO_4)_2$	47.18
$(UO_3)_2$, Fe_2O_3, P_2O_5	4.95
Al_2O_3	6.33
CaO	6.64
MgO	1.98
H_2O (ignition)	13.28
Total	98.91

As Packard remarks, the above result clearly indicates that the material was not entirely free from impurities. A second weighed portion was accordingly selected amounting to 0.5120 gram of the dull lemon- or sulphur-yellow mineral and treated with HNO_3, which after digestion left a residue weighing 0.2460 gram, yielding 0.2660 gram for analysis. This gave: $U(UO_4)_2$ 61.28, corresponding to 60.14 per cent of UO_2; CaO 6.01.

Accepting then the percentages of SiO_2 and H_2O in the first analysis, and those of UO_3 and CaO in the last, as representing the composition of the mineral; and disregarding the percentages of Fe_2O_3, Al_2O_3, MgO and P_2O_5, and recalculating the four essential oxides to a basis of 100, the ratios become:

	I.	II.	III		
CaO	6.01	6.14	.109	=	1
UO^3	60.14	61.37	.213	=	1.95
SiO^2	18.55	18.93	.315	=	2.88
H^2O	13.28	13.56	.753	=	6.90
	97.98	100			

I. Analysis of uranophane from Stone Mountain, Georgia, from which the small percentages of Al_2O_3, Fe_2O_3, MgO and P_2O_5 are omitted.

II. Analysis I recalculated to a basis of 100.

III. Molecular ratios of II.

The molecular proportions given under column III correspond to the formula $CaO.2UO_3.3SiO_2 + 7H_2O$, which indicates one part more of SiO_2 and H_2O than is required by the formula for uranophane, $CaO.2UO_3.2SiO_2 + 6H_2O$. The dis-

crepancy in these two constituents is easily accounted for, however. The SiO^2 is increased by the presence of finely divided mineral particles from the granite and hyalite, it being quite impossible to effect a complete separation of the uranophane from these two. The amount of available material was so small that it was impossible to separately determine the combined and uncombined water, and under the total water given in the analysis, it is reasonable, at least, to assume that a small fraction of it is hygroscopic (uncombined) water. What now appears then as a slight variation from the exact formula for uranophane, disappears when the above facts are considered.

A comparison of the above analysis of the Georgia mineral with several by Genth and von Foullon of the uranophane from Mitchell County, North Carolina, and one from Kupferberg, Silesia, quoted by Dana,[1] shows very close agreement. The reported occurrence of uranophane in granite at Kupferberg in Silesia appears in this particular to be similar to that in Georgia.

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[1]Op. cit.

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[1]Op. cit.